Using Land Use Policy to Address Congestion: The Importance of Destination in Determining Transit Share

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ABSTRACT

Given the costs and political difficulties inherent in urban highway expansion, one of the few options available for policy makers hoping to reduce congestion is to increase the use of non-auto travel modes, especially transit. However, it is difficult to substantially impact transit use at a large scale because it is strongly dependent on development density and other slow-changing features of urban land use.

This paper argues that policy makers hoping to reduce congestion through increased transit use should focus on increasing the size of downtowns, and on developing downtown-like centers in suburban locations. There are both empirical and practical arguments. Empirically, large, dense destinations have a very substantial impact on mode choice, regardless of the characteristics of the trip origin. Much of the apparent impact of residential density on mode choice is actually due to the fact that residents of high-density areas are more likely to work in a downtown.

There are two practical arguments for focusing on downtown-style development rather than increasing residential densities. First, it will probably be easier to increase densities in commercial areas, both because political opposition is less acute, and because developable land is often more available. Second, commercial areas can be developed at densities an order of magnitude higher than residential neighborhoods, with a corresponding impact on transit ridership.

INTRODUCTION

There are few options available for policy makers hoping to manage the problem of urban traffic congestion. One of these involves reducing the number of cars on the road by shifting trips to transit. However, although transit has generally been holding its own over the last few years, there have been few if any major examples where transit share has substantially increased as a result of policy intervention.

One likely reason for this is that transit use is highly dependent on the nature of the urban land use in which transit operates. A multitude of studies have confirmed the link between residential population density and the share of trips made by transit. The link, indeed, is so well established that the most visible recent literature is concerned more with identifying specific characteristics of neighborhood design that are important to the decision to use transit. Boarnet and Crane (1) provide an extensive recent survey of the literature on the effect of urban design characteristics on transit share and other travel behavior measures.

However, a critical issue in this debate is the relative lack of acknowledgement of the role that trip destinations play in determining transit use. The work of Calthorpe (2), for example, has been very influential among policy makers, but is focused on residential neighborhood characteristics. Some studies, such as Cervero and Gorham (3), do include measures such as access to downtown in the analysis, however actual differences in destination choice, as opposed to hypothetical access measures, are usually not considered. Frank and Pivo (4) are an exception; they find a “dramatic increase” in transit use at high employment densities. However, they do not place this finding within a broader context of overall urbanized area transit share.

A significant work that did address the destination as a key contributor to transit use was Pushkarev and Zupan (5). However, their conclusions about the importance of employment density in determining transit use do not seem to have had much influence on the models and methodologies employed in recent studies, despite the high quality and comprehensiveness of their work. Indeed, many of the results and arguments in the present paper appeared in Pushkarev and Zupan 25 years ago; given recent hopes for using transit as a congestion management tool, it seems like a good time to bring them up again.

Table 1 illustrates the importance of the central business district (CBD) in determining overall urbanized area transit share. A more formal analysis of the 31 largest U.S. urbanized areas in Barnes (6) found that a measure of the localized density of employment (essentially a proxy for the size and density of the downtown) explained considerably more of the variation in transit share across cities than did measures of residential density.

The omission of destination choice from transit share analyses is important from a methodological standpoint because differences in transit share across neighborhoods or even urban areas may be inappropriately attributed to residential characteristics when they are really due to differing destination choices. It is also important from a policy

perspective because the overwhelming focus on residential characteristics can give policy makers the impression that nothing else matters.

The purpose of this paper is to make the case that destination choice not only is a critical variable in the determination of transit use, but that from a policy standpoint it is more important than residential characteristics. Empirically, it matters not only because the overall transit share from a given trip origin is strongly dependent on the destination, but also because the relative impact of origin residential density is very different across destinations.

Perhaps even more importantly, transit destination matters to policy because it is, as a practical matter, considerably easier to have a substantial impact on commercial areas than on home locations. As a political reality, it is normally very unlikely that residents of existing neighborhoods will accept substantial increases in density, so new developments are the only real opportunity for impact. And even here, there are limits to how dense development can be for both political and economic reasons. However, these constraints are not true to the same extent of commercial areas. Downtown areas are routinely developed at extremely high job densities. And proposed increases in the size or density of commercial areas rarely provoke the kind of opposition that routinely occurs when changes are proposed to residential areas.

The second part of this paper contains a simple empirical analysis of transit use in the Minneapolis-St. Paul metropolitan area. The objective is to clarify the impact of trip destination relative to origin neighborhood characteristics, and to establish that this is a variable that matters a great deal. The third part of the paper discusses from a theoretical and political perspective, based on these results, why commercial land use, rather than residential, represents a more viable policy option for influencing transit use.

EMPIRICAL ANALYSIS

This paper is based on work done as part of the multi-year Transportation and Regional Growth Study carried out at the University of Minnesota; thus the example used here is the Minneapolis-St. Paul (Twin Cities) metropolitan area. This is a seven-county region with about 2.5 million residents. There are two separate downtowns about ten miles apart; the two central cities abut each other and have about 650,000 residents between them. This analysis uses an aggregation of the 1,165 traffic analysis zones into 66 larger "zones." These are loosely based on political boundaries with the objectives of maintaining roughly similar populations across zones, and uniform land uses within zones. Thus some small cities and towns are combined, and some large cities broken into multiple zones. Except for three cases (the two downtowns and the airport), all the zones have at least 10,000 residents.

The zone corresponding to the Minneapolis downtown has about 125,000 jobs in about two square miles. The St. Paul downtown has about 60,000 jobs in a slightly smaller area. In both cases the jobs are concentrated in the center of the zone. The Minneapolis campus of the University of Minnesota constitutes a third subcenter of about 35,000 jobs; after this job densities are much lower in the rest of the region. While some suburban zones have many jobs, they are spread out over very large land areas, and are

thus very difficult to serve effectively with transit. As a result, much of the transit service in the region is focused around the two downtowns.

The analysis uses 1990 census transportation planning package (CTPP) data for the Twin Cities to analyze the relative impacts of destination, residential density, and a number of other variables in determining transit share for work trips. The densest residential zone has about 13,500 people per square mile, the second densest is about 9,000. About a third of the zones are essentially non-urbanized, with densities below 1,000 per square mile. About a third of the zones have overall work trip transit shares below 2%, another third are between 2% and 5%, and the final third are higher than 5%. About half of these have shares in excess of 15%, up to a maximum of 27%. The overall density of the urbanized part of the region is about 2,000 per square mile; the overall work trip transit share in 1990 was 5.9%.

A Simple Analysis

An initial illustration of the importance of the destination aggregates the zones into three area types. The first consists of all zones that are not in one of the two central cities. The second is central city zones, excluding the downtowns. The third area consists of the two downtowns. Table 2 shows the work trip transit share from each origin area type to each destination area type.

While the importance of the origin is further confirmed by the fact that central city residents are considerably more likely to use transit to access all destinations, the key point for purposes of this paper is the very high transit shares into the downtown areas relative to the rest of the central cities. A relatively high share is obtained even from non-central city origins, which includes a huge area, most of which has little if any easily accessible transit service. It is also worth noting that this is based on 1990 data; express service into the downtowns from suburban areas was expanded considerably during the 1990s in the Twin Cities, so the difference between origins may be even smaller now.

Another interesting point from Table 2 is that the downtowns, while not particularly densely populated, generate very high transit shares by their residents. The key point in transit use is not the density of people, it is the density of buses, and bus density can be justified by jobs as well as residents. The residents piggyback on the huge number of jobs to gain access to a level of transit service, especially to non-downtown destinations, that their own numbers would never justify.

Failure to account for differences in destination choice can lead to inappropriate conclusions regarding the importance of various origin characteristics; there is particular reason to be concerned about this issue in studies that compare “matched pairs” of origins. For example, Table 3 shows an example of two (hypothetical) central city origins, which differ only in the fraction of their workers who commute into downtown versus the suburbs. The fact that origin 2 has more people working downtown, and fewer in the suburbs, leads to a 5.3% increase in transit share compared to origin 1, even when the transit shares broken down by destination are identical.

Explaining this large difference in transit share by reference to land use or other characteristics of the origins would be incorrect; the only important difference between them is that their workers are not commuting to the same places. The opposite problem

could also occur. Two origins that really were generating different transit behaviors might end up appearing similar because differing destination choices could cancel the differences out.

Table 4 shows the same origin to destination transit shares as Table 2, but with Minneapolis and St. Paul broken out separately.

The overall population density of the city of Minneapolis is about 6,500 per square mile, and of St. Paul about 5,000. Again, residential density matters; for each destination, the cities generate higher transit shares than the rest of the region, and Minneapolis exceeds St. Paul. But destination is still a key contributor; for each area, trips to a downtown are generally about three times more likely to use transit than are trips to other locations in the same city.

Regression Analysis

A second, more detailed analysis involved a series a regressions, using origin zone transit shares to various destinations as the dependent variable. The regressors were population density, an income measure, and distance of the zone from the nearest downtown. The income measures were average zonal income, and the fraction of households in the zone with income below $25,000 (1990 dollars). The second of these turned out to be the superior variable in terms of significance and explanatory power. The distance of the zone from downtown was never significant when included in a regression with population density, thus it is omitted here.

One final point is that the downtown zones, as noted earlier, generated transit shares as origins that were quite disproportionate to their density and income characteristics; to the extent that they substantially distorted the regression results. Thus these two zones were omitted; the regressions were run using the other 64 origin zones.

For every destination, population density (in thousands of people per square mile) and percent of total households with low incomes were always statistically significant, and no other variable ever was when included with these two. Table 5 shows the regression results for the three destination types, and for overall transit share. The entry of "0" indicates a result that was not statistically significant. All other entries are significant at a 5% level or better. The R squared figures indicate that about 80% of the variation in transit share across zones was explained by differences in these two variables.

The interpretation of these numbers would mean, for example, that an extra 1,000 people per square mile in a given area would add 1.49 percentage points to the overall transit share for that area, and an extra 1% of the households having low incomes would add 0.45 percentage points, if the work destinations are the "average" for the region. However, in a residential zone where everyone worked in the suburbs, such as might happen in an exurban development, the same density increase of 1,000 per square mile would increase the transit share by only 0.63 percentage points.

The key point here is that higher residential population density has a much bigger impact on transit share for trips that are going to downtown areas. The impact is roughly twice as big as it is for other central city destinations, and four times bigger than for

suburban destinations. Residential neighborhood characteristics matter, but the extent to which they matter is very strongly influenced by where people are going. Another interesting result is the very high intercept for trips to downtown; this represents essentially the "worst case" transit share. Thus a population density of just 1,000 per square mile would generate a transit share of 8.73% into downtown (the intercept of 6.3 plus the density increment of 2.43); it would take a density of 7,500 per square mile to get the same transit share to other central city destinations (no intercept, and a density increment of 1.15). Even more striking, it would take a density of 16,000 per square mile (denser than any zone in the Twin Cities) to get an 8.73% transit share from an origin where everyone works in the suburbs (intercept of –1.4, plus a density increment of 0.63). This could raise questions about the likely efficacy of new high-density developments on the urban fringe, in terms of increasing transit use.

There is an important policy point here. There has been much discussion in the literature and among policy makers of the need for higher density development as a prelude to higher transit use. But the relationship between residential density and transit use is not as simple as it is often portrayed. The impact of higher density is very strongly dependent on where the residents work. From a transit perspective, small increases in the density of central neighborhoods will have a bigger payoff than large increases in new developments on the edge, because residents of edge developments are relatively unlikely to work in the transit-rich downtowns.

Many studies have pointed to the cost of parking as a key factor influencing the level of transit use into downtown areas. It would be difficult to directly determine the influence of parking costs here as the downtowns are virtually the only areas that have parking costs. But here the objective is not to explain what it is about the downtowns that is responsible for the high transit use, but simply to establish that they are qualitatively different from everyplace else. The question of how they are different is addressed in the next section.

ADVANTAGES OF FOCUS ON COMMERCIAL DEVELOPMENT

The focus of this study is the explicit identification of the work trip destination as an important variable in determining transit share; it influences both the overall share, and how changes to residential density impact transit use. While most of the literature focuses on residential density, the finding in the previous section is that there are two different land use tools for influencing transit use: increases in residential density and the development of large, dense, commercial centers. The second purpose of this paper is to argue that the latter of these is actually the better policy tool, both politically and from the standpoint of the potential impact.

Constraints on Residential Development Density

While it may be true that in most American cities there is more demand for than supply of high-density residential environments, it is also probably true that the number of people desiring to live in such an environment, who do not already do so, is probably not large enough to impact regional transit use very much. This is especially the case if the new high-density developments are in outlying areas where residents are unlikely to

work downtown. Creating a significant regional increase in transit use would be much easier if somehow transit use could also be increased among all the people that are already housed in lower-density environments. From the standpoint of using residential development as the lever, this would require increasing the density of existing neighborhoods.

And in this case there is the problem of convincing the existing residents, who tend to have two issues with new development. First, the reason they moved to the area was because they liked the environment, so they will oppose anything that changes it much. Second, rightly or wrongly, people see high-density and especially rental housing as attracting undesirable types of residents. Many, perhaps most, of the recent examples of high-density residential redevelopment in the Twin Cities have arisen on reclaimed commercial and industrial properties in and near the downtowns and the University of Minnesota, where there are few if any neighbors to object to them.

Cervero and Landis (7), in a study of the land use impacts of San Francisco's BART rail system, concluded that the system has had little impact on land use outside downtown in large part for this reason; existing neighborhoods had no interest in being redeveloped around transit stations. From a transit perspective, it is undoubtedly better to develop residential areas at higher densities rather than lower, but as a political matter there appear to be significant constraints on how much impact this strategy can have.

Even if politics were not an issue, Guiliano (8) has noted that significant residential land use changes are unlikely simply because housing structures maintain their usefulness and value, and hence are very long lived. People routinely live in housing structures that are decades or even hundreds of years old; it is typically not cost effective to tear down a well-maintained house and replace it with something else, because the house will still have value to someone. Since the housing stock changes so slowly, it will be difficult to have major impacts on overall density patterns by focusing on this exclusively.

Yet another constraint on the impact of residential density increases is that there is a relatively low upper bound on how high residential density can reasonably go. Very high densities require either small spaces or tall buildings, or both; again, most people seem to see these two characteristics as problems rather than attractions. Only a handful of very large cities have substantial areas that are both high-density and high rent.

But from a transit standpoint densities should be as high as possible. Given the above findings, an area of 10,000 per square mile would generate about a 15% transit share on average, or 1,500 total transit riders per square mile. An area of 20,000 per square mile would generate a 30% transit share, or 6,000 total riders. That is, a doubling of density would normally double the transit share *and* the number of people involved, for a quadrupling of total transit ridership.

Thus the impact of residential density is limited by three factors: political constraints, the slow turnover of the housing stock, and practical limits on density. However, these constraints are not true to the same extent of commercial areas.

Advantages of Focus on Commercial Development

Compared to residential redevelopment, the political barriers to commercial land use changes seem to be generally less significant. Major commercial developments in the Twin Cities, to the extent that they provoke any public controversy at all, tend to generate concerns about the relatively manageable issues of traffic and parking. Given that these issues can be addressed, surrounding businesses and their workers do not in general seem to feel that their quality of life will be negatively impacted by the presence of additional businesses and workers nearby. Empirically, the areas around the two Twin Cities downtowns and the University of Minnesota have accommodated a very sizable amount of new development (both commercial and residential) in the last ten years; no established residential neighborhood has seen anything remotely comparable.

In addition to the simplified political issues, another possible explanation for why most new "infill" development seems to take place on reclaimed commercial and industrial properties is that large developable parcels of land seem to be more available in this context. Technologies and markets change over time; as a result buildings sometimes become inadequate for their intended purpose, and can't easily be adapted for other uses. This relatively frequent availability of significant areas of centrally-located land, which does not seem to occur as often in residential areas, adds to the potential to aggregate a substantial fraction of the region's jobs (and at least some of its housing) into a few very large, dense centers, which can be effectively served with transit.

In terms of achievable densities, downtown areas are routinely developed at job densities that exceed the highest residential densities of their cities by a factor of five or more (*6*). And high densities mean high transit shares; combined with a large number of jobs this means a lot of transit users: the two Twin Cities downtowns are responsible for 60% of the transit work trips in the region, although they contain only 15% of the jobs.

As a simple example of the potential impact, suppose that the number of jobs located in the downtowns were twice what it is now; that is, 30% of the total rather than 15%. Then given the transit shares into the downtowns (22%) versus the rest of the region (2.9%), the overall transit share for the region would rise from 5.9% to 8.9%. To achieve the same increase through higher residential density would, according to the earlier results, require an average density increase of 2,000 per square mile across the region, or roughly a doubling of the average urbanized area density. Commercial land use changes of this magnitude are, at least in principle, politically and financially feasible; residential land use changes of this magnitude probably aren't.

A related point is the location of non-work destinations such as retail, entertainment, and educational opportunities. Again, much of the literature has focused on the importance of mixing these land uses in with residential development. But the probability that people will access these activities using non-auto modes should increase considerably when they are located in big, dense centers, for many of the same reasons as are true for trips to work. People will only use transit to access shopping if there is transit service, and even major regional malls have very limited service compared to a downtown; small neighborhood shopping districts might be served by only three buses an hour, from each of two directions. And people will usually walk to shopping only if the walk is relatively short; only in a downtown-like environment are a large number of

people within a short walk of a large variety of opportunities. The presence of such activities also makes the area more attractive as a work location.

Generating High Transit Share

As noted earlier, the presence of parking charges in downtown areas is probably responsible for a significant fraction of the very high transit shares that are observed there. Development of large dense commercial centers is probably not enough in itself to guarantee high transit shares; there must also be a commitment to the imposition of relatively high parking costs. At the same time, high parking costs are also not a sufficient condition when taken alone. Parking charges increase transit use by making transit relatively cheaper compared with driving; but this effect cannot occur unless reasonable transit service is available in the first place. Attempting to impose parking costs on a sprawling suburban job center where there is little transit service available, would be politically a very hard sell.

The point here is that frequent transit service to a place becomes viable when there are a lot of customers; this in turn requires both a large number of potential customers and a relatively high transit share. A high transit share, in turn, comes about because transit service is competitive with auto travel; monetary cost is one aspect of this, and travel time is another. Competitive travel times are much more likely when buses can travel on freeways (for longer distance trips) and when they don't have to make many stops at the end of the trip. Non-stop travel on freeways is viable when there is a reasonable load of passengers going to the same place; typically only a big destination is likely to generate this.

And quick discharge at the end of the trip is possible only when most of the possible destination buildings are close together, so that everyone can reasonably walk to their building from one of a small number of closely spaced stops. This is critical because, unlike the home end of the trip where there are many options for accessing transit, generally walking is the only available option at the work end. In a downtown, because the buildings are tall and close together, there are tens of thousands of jobs within walking distance of any bus route.

In suburban areas, by contrast, buildings are generally separated by wide, high-speed streets, long distances, and large surface parking lots, so that a bus would almost have to stop at every building individually, likely with a gap of three minutes or more between each stop. In other words, simply increasing suburban service frequency to downtown levels will not have the impact that it does in downtown; even if there are more options and less waiting time; the buses themselves will still be too slow due to the large number of stops they would need to make. And of course providing such service would be financially burdensome in the absence of the high transit use needed to offset the costs.

CONCLUSION

Planners and policy makers hoping to manage urban traffic congestion through increased transit use are limited in the short term by the strong influence that existing land use

exerts on mode choice. While this point has been widely acknowledged, most research and policy discussion on this topic has focused on increasing residential densities. However, the conclusion of this paper is that the development and expansion of very large, high-density job centers is the best tool available for most cities to achieve substantial increases in transit use.

Increasing transit use ultimately requires improved service or higher costs of driving, such as parking charges. Higher parking charges will be politically infeasible in the absence of adequate transit service as an alternative; improved transit service is hard to justify in the absence of a sufficiently large market.

Creating a large market appears to reduce to two options: the well-known solution of increasing residential density, and the less-considered option of focusing on the work end of the trip. While both of these tactics appear to be effective, it is, for a variety of reasons discussed here, very difficult to have impacts on residential density that are large enough to have regional significance.

The constraints that limit the use of residential density increases as a tool are not in force to nearly the same extent for commercial development. A gradual transition of a relatively small amount of office space from isolated or low-density settings into a few large dense centers could lead to sizable increases in regional transit use in a relatively short time. Such focus on the work end of the trip, by making increased transit service more viable, could also help to increase non-auto access to retail and other non-work opportunities. And it may be the only tool available for inducing significant transit use from the vast suburban areas of most cities that are already developed at low densities, and which will probably stay that way forever.

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LIST OF TABLES

TABLE 1 Transit Share and Destination Across Cities (1990)

	Transit share to CBD	Transit share to non-CBD destinations	Percent of total regional jobs in CBD	Overall urbanized area transit share
Los Angeles	14.3	3.8	5.2	4.3
Atlanta	15.7	3.7	9.5	4.8
Pittsburgh	29	3.6	20.1	8.7
Philadelphia	41.3	6.7	14	11.5

TABLE 2 Origin to Destination Transit Shares

From Row to Column	Non-CC	CC	DT
Non Central City	0.57	3.53	15.85
Central City	4.78	11.13	31.22
Downtowns	18.80	35.47	17.56

TABLE 3 Impact of Differing Destinations on Transit Share

	Transit share to destination	Percent working at each destination (origin 1)	Percent working at each destination (origin 2)
Non Central City	4.78	40	20
Central City	11.13	40	40
Downtowns	31.22	20	40
Total transit share		12.6	17.9

TABLE 4 Detailed Origin to Destination Transit Shares

From Row to Column	Non-CC	Mpls.	St. Paul	Mpls. DT	St. Paul DT
Non Central City	0.57	4.46	2.24	19.37	8.54
Minneapolis	5.71	13.30	10.42	37.05	15.62
St. Paul	3.26	10.27	8.50	21.90	25.33

TABLE 5 Regression Results

	Intercept	Population density beta	Low income beta	R squared
To Downtown	6.3	2.43	0.70	.76
To Central City	0	1.15	0.31	.83
To Suburbs	-1.4	0.63	0.19	.80
All Destinations	-1.9	1.49	0.45	.86